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Issued January 13, 1913.

U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF PLANT INDUSTRY—BULLETIN NO. 258.
B. T. GALLOWAY, *Chief of Bureau.*

SOME NEW ALFALFA VARIETIES FOR PASTURES.

BY

GEORGE W. OLIVER, *Plant Breeder and Propagator.*

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., June 1, 1912.

Sir: I have the honor to transmit herewith a manuscript entitled "Some New Alfalfa Varieties for Pastures," by Mr. George W. Oliver, Plant Breeder and Propagator, and recommend that it be published as Bulletin No. 258 of the series of this bureau.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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B. P. I.—761.

SOME NEW ALFALFA VARIETIES FOR PASTURES.

INTRODUCTION.

The lines of investigation worked out in this paper were briefly outlined to the writer a few years ago by Dr. B. T. Galloway. The material experimented with includes numerous plants of the Grimm, Turkestan, Baltic, and Mongolian alfalfas, obtained from many sources, including the strains raised by Prof. W. A. Wheeler, of South Dakota, and the selections of hardy plants made by Mr. John M. Westgate and Mr. Charles J. Brand, of the Bureau of Plant Industry. The valuable collections obtained in foreign countries by Mr. Frank N. Meyer, one of the agricultural explorers of the Bureau of Plant Industry, and the plants selected abroad by Prof. N. E. Hansen, of the South Dakota State College of Agriculture, have all been utilized in breeding new races of alfalfa.

The first work undertaken with the large amount of material available was to become familiar with the characters peculiar to each of the widely different groups. During the progress of this investigation important characters were found which in the different groups seem correlated with hardiness and drought resistance. These characters consist of the underground development of rhizomes and modified rhizomes.

In the numerous crosses which have been made at the Department of Agriculture during the last three summers much attention has been given to these underground characters, because the alfalfa which has a root system that assures hundreds of resting buds, in some cases no less than 12 inches below the surface of the soil, is the variety which may be expected to withstand semiarctic conditions. Other plants with very large succulent rhizomes several feet in length evidently function during protracted dry spells partly through their storage of water.

A large number of crosses have been developed, in most cases only to the first generation. Many of the plants have been fruited and seedlings of the second generation raised. The principal object in

making these crosses is not so much the improvement of the strains now growing in this country as it is to provide strains adapted to pasturage which will succeed in the large areas where alfalfa is not grown at all.

In so far as the project has progressed, the outcome is highly promising. The Department of Agriculture, however, has as yet nothing to distribute and will not have until the crosses are an assured success in the areas referred to.

During the study of perhaps the largest number of what are considered distinct species and forms ever brought together in a single collection, it becomes evident that until recently very little has been ascertained concerning the life history of the alfalfas of the world. They are a much mixed lot of plants, as scarcely any of them, even when gathered in localities where they seem to be native, come invariably true from seed. This unfortunate condition is due to the cross-pollination of the flowers by insects, but it is possible to breed them to come true to type, and the result is worth the effort necessary to accomplish it.

During the progress of the initial stages of breeding alfalfa for different sections of the country it became evident that the extensive rhizome development of some of the wild forms, so far as the writer has been able to ascertain, has never been taken into consideration in hybridizing work to perfect hardy and drought-resistant strains.

The hybrid combinations are startling in their abundant growth, both above and below ground. This bulletin has been written partly to call attention to these characters and partly to place on record a number of crosses already made.

PROVISION FOR THE PERPETUATION OF TYPES IN ALFALFAS COMPARED WITH COWPEAS.

In the first generation of a cross between two varieties of the cowpea each plant is like its neighbor, and no difference can be detected in, say, 12 plants, which number is frequently secured in a single cross. The habit of growth, color, size, and shape of pod and the color, size, and shape of seeds are in each case alike. The flowers of the parents are self-pollinating and the plants of a fixed variety come true from seed, because each stigma is pollinated with the pollen of its own flower. When, however, the flowers of two plants are crossed and these two plants are dissimilar in many or few characters, such as spreading and upright habits, and the seeds are different in their markings, one, for instance, being white with a black eye and the other speckled like the Whippoorwill variety, the progeny in this first generation will have black seeds. In the second generation the color combinations, also the size and form of seed, are numerous;

sometimes in as many as 16 series of plants observed the seeds of any one series are entirely unlike those of the other 15. In the next sowing the seeds of each plant of the second generation are sown separately and only those in this, the third, generation which resemble those of the second are again saved. If they continue to come true in the next, or the fourth, generation, they will always come true.

With alfalfas, however, a very different problem is presented, in that very often the parents selected do not come true even from seeds resulting from flowers which have been self-pollinated. The reason for this is that the flowers are perfectly constructed for intercrossing. A seed parent selected for crossing sometimes gives over a dozen distinct forms when inbred. All of these when inbred again do not come true, but occasionally a plant will be found which has the characters of the original plant. This absolutely essential preparation for crossing requires at least two seasons before one can be reasonably certain that he has parents which are fixed enough in the desired characters to begin hybridizing.

THE ALFALFAS OF NORTHERN AFRICA.

Dr. B. T. Galloway, while abroad last year, discovered a large number of alfalfas in flower, many of which looked promising, none of which he had seen in the United States. Later in the summer, seeds of all these plants were collected by the writer, chiefly in northern Africa. Most of them were found in abandoned patches of exceedingly poor soil at one time cultivated by Arabs. The manner of their occurrence suggests that they are introduced rather than native species. Whatever their origin, more species and forms of alfalfa occur in northern Africa than have been reported in any other region of the world.

Most of these forms have never been tried on American farms. Some of the plants from which seeds were imported are puzzles in a botanical classification. Among the number there are tall, strictly upright forms with glutinous hairs and large yellow flowers which perhaps belong to the form known as *Medicago sativa glutinosa.* Others of this class have bluish green flowers, between those of *M. sativa glutinosa* and *M. sativa glandulosa.* Some again have falcate pods studded with glandular hairs, probably crosses between *M. falcata* and *M. sativa glutinosa.* Some plants of exceedingly upright growth and showing every indication of being typical *M. sativa* had the telltale glandular pubescence on the pods. Some of these plants have more seeds to the individual than any hitherto recorded. Seedlings from all these plants, including 49 forms, are now growing at Washington and they will be used shortly on a small scale for testing, so that a study can be made of them as a basis for future hydridizing.

A plant which seems to be nearest *Medicago sativa gaetula* was found a few miles west of Algiers. This plant has longer rhizomes than any other wild alfalfa received by the Department of Agriculture. Some rhizomes developed on a specimen brought to Washington which are over 3 feet 6 inches in length. (Pl. I, fig. 1.) One plant observed covered an area of fully 9 square feet. The rooted growths of the previous season were easily traced to the mother plant, which was evidently little more than a 1-year-old seedling. In the case of older plants it was difficult to disentangle the rhizome growths. This plant has purplish yellow flowers and glandular hairy pods. Its nature seems to fit it for growth in arid regions, especially in sandy soils or in those not liable to become hard. There is a possibility that this plant may be found to endure considerable cold, as the rhizomes are very deep in the soil.

WILD RHIZOME-FORMING ALFALFAS.

Mr. Frank N. Meyer has been very successful in securing seeds and plants of rare alfalfas, some of which show rhizome development far in excess of any of our cultivated forms, with the exception of *Medicago sativa gaetula*. These alfalfas include forms of *M. falcata* which, together with the forms secured by Prof. Hansen, show a variation in height from a few inches to 5 feet 8 inches. These plants vary widely in their underground characters, in that some from very cold regions have exceedingly long taproots which evidently do not branch until they are several feet in the ground. A plant of this nature obtained by Mr. Meyer in Siberia is seen in Plate II, figure 1. Another very hardy form does not produce a taproot, but has a branching type of root. This is S. P. I. No. 20721.[1] Plants of *M. falcata* found in the Caucasus and Crimean regions, which are said to be protected during the winter by a deep covering of snow, show absolutely no signs of taproots, but their long rhizomes are well developed and produce roots along their entire length. (Pl. XI, fig. 2.) Late in the fall the tips of these rhizomes come to the surface or near it. Those which have small leaves above the surface do not seem to suffer in the least when exposed without any covering to a temperature of —13° F.

All these plants have been used in crossing with diverse strains, such as the Grimms, Turkestans, and others. The dwarf *Medicago falcata* has been crossed with a taller growing rhizome-bearing form of the same species. The winter condition of this hybrid is seen in

[1] The letters "S. P. I." stand for "Seed and Plant Introduction," and the numbers refer to the series of plants and seeds brought into the United States by the Office of Foreign Seed and Plant Introduction of the Bureau of Plant Industry.

Plate III, figure 1. The rhizomes go down in the ground to a depth of over 12 inches. (Pl. III, fig. 2.)

There are exceedingly dissimilar types of *M. falcata*, all of which for want of descriptive specific and varietal names must be classed under a single name. The plant to which Linnæus gave the name *falcata* was a prostrate form, but to what extent it was prostrate will perhaps never be known, as herbarium specimens of prostrate forms might be easily mistaken for decumbent ones.

Between the two extremes in height mentioned, forms characterized by other differences are found, such as semiprostrate and decumbent forms, some with hairy pods perfectly straight, others sickle shaped, some with smooth pods, some black, others brown, and some of them even with glandular pubescence. In the foliage there are quite as many variations; broad, narrow, flabby, hard, dark green to bluish green, some with a great profusion of flowers, others with but few, and all of them shy seeders, possibly on account of a seemingly meager supply of pollen grains. The pods of most of them shatter badly, but Mr. Meyer has found a strain in Siberia which does not shatter.

NEW RHIZOME-FORMING ALFALFA HYBRIDS.

Among the numerous consignments consisting of several species and varieties of alfalfa received in recent years by the Office of Foreign Seed and Plant Introduction a few of the plants gave decided promise as parents of new strains for pasturage purposes.

These alfalfas have been under observation for three seasons. They are natives of the Crimea and the Caucasus. Their principal claim to attention is their ability to bury the resting buds of the rhizomes several inches under the soil, which not only insures a crop of branches for the following season by reason of considerable protection from low temperatures, but also prevents the destruction of the plants by browsing animals. Among the new plants there is considerable diversity in habit of growth. Some of them are quite prostrate, never attaining a height over 6 inches. Some of these, however, give a fairly large quantity of forage, but on account of their prostrate natures can not very well be converted into dry fodder. Some of the forms have bluish purple flowers and very small, dark-colored, twisted pods. Other forms are between the last-named and the semi-upright forms of *Medicago falcata*. None of them is of strictly upright growth to such an extent that it could be harvested by ordinary methods. Even in their present condition, some of these prostrate forms are fairly well adapted to grazing purposes and in this capacity they would probably excel all

other low-growing legumes. However, there are some which are quite prostrate and which do not have rooting rhizomes and some which are without rhizomes of any description.

During the summer of 1910 the best of these prostrate plants, which were well provided with deeply set rhizomes, were crossed with forms of *Medicago falcata*, which also showed good rhizome development but almost prostrate growth above ground. These hybrid strains are being developed for the several areas where ordinary alfalfa does not succeed. Plate III, figure 1, gives a fair idea of their ability to withstand extremes of drought and cold. During the summer the plants were repeatedly cut over at a point 1 inch below the surface of the soil. When finally they were allowed to grow they made a more rampant growth than those plants which were left uncut. (Pl. IV, fig. 1.)

In order to obtain moderately large quantities of seeds quickly vegetative propagation will have to be resorted to. One man can place in sand enough cuttings in one day to plant a quarter of an acre in rows 3 feet apart, the plants 18 inches apart in the rows. The cuttings are easily manipulated. It is only necessary to cut them with a sharp knife, each cutting to be 3 to 5 inches long, according to the variety and the condition of growth, remove the lower leaves, and set in sand. When kept cool, moist, and protected from sunshine they root within three weeks. They are then placed in flats of soil; within 10 days strong roots are formed. (Pl. V, fig. 1.) After a rain they are transferred to permanent quarters in the field. The plants will, in a measure, take care of themselves. If any large overshadowing weeds make their appearance they should be cut down until the young alfalfa plants have ripened a crop of seed. Plate III, figure 1, shows a plant from an 8-inch pot. The cutting from which this plant grew was rooted in May, 1911, and the photograph was taken in October of the same year.

These new rhizome-forming alfalfas will probably succeed best in the Northwestern and Eastern States having limestone soils. They do not succeed so well in heavy soils as they do in soils having a considerable proportion of sand. There is also a possibility that some of the hybrid forms will thrive in the semiarid regions of the country.

DEVELOPMENT OF ROOTING RHIZOMES OF PASTURAGE ALFALFA HYBRIDS.

It is exceedingly interesting to watch the development of the rooting rhizomes on the artificial hybrids. Sometimes rhizomes develop on the seedlings when only a few weeks old. A good example is a young plant of cross No. 284 (see Pl. X, fig. 2), which

has as its parents Grimm, F. C. I.[1] ♂ No. 138 ♀ × S. P. I. No. 28042. The latter is thought to be a form of *Medicago sativa gaetula*. A mature plant of this cross is seen in Plate VI. The seedling mentioned has the rhizomes attached to the root fully 3 inches below the bases of the lowest buds, which are situated immediately above the cotyledon scars. Cases of this nature must be somewhat rare, as they have been found by the writer only in this cross.

Other plants of this cross, examined eight months after they were planted out, show the point of attachment of the rhizomes to be the basal portions of the original branches from the axils of the cotyledons. These rhizomes begin their growth within two months after germination. (Pl. VII, fig. 1.) By the end of September several growths above ground were formed at a distance of 10 inches from the main crown, and from the bases of these growths a large crop of rhizomes are again formed before the advent of cold weather. (Pl. VI.) Many of the individuals of the crosses, especially those in which the Peruvian alfalfa has been crossed with a plant having very long underground rooting rhizomes, show a condition the significance of which can not be predicted with certainty. The growth above ground is strictly upright. The dormant rhizomes are much divided and very stout; in several instances they are from 3 to 6 inches below the soil surface. If these turn out to be of the rooting form, we shall have a desirable type of alfalfa very different from any now in cultivation.

RHIZOMES AND THEIR FUNCTIONS.

The rudiments, at least, of underground rhizomes have been found on all the very hardy species of alfalfa and their numerous forms found in a wild state.

Through hybridization these rhizomes in a modified form are more or less present in nearly all of the hardy and semihardy strains now growing in the United States and Canada. All the strains grown by the writer, including those bred from selected plants by Prof. Wheeler, of South Dakota, and also numerous selected plants of hardy Grimm alfalfas (Pl. VIII, fig. 1) and other varieties secured by Mr. Westgate, of the Bureau of Plant Industry, together with plants secured by the writer from many other sources, show modified rhizomes.

In the greater number of plants the bases from which these underground shoots are produced are several inches beneath the surface.

[1] The letters "F. C. I." stand for "Forage-Crop Investigations," and the numbers refer to the series of plants and seeds used in the investigations of the Office of Forage-Crop Investigations of the Bureau of Plant Industry.

It has also been found that a number of plants produce roots from these modified rhizomes. This peculiarity is responsible for the so-called stooling of many plants in hardy strains. The function of the rhizome and its modifications is undoubtedly to produce a large quantity of growth above ground and to protect the lower winter buds, which are situated well below the surface of the soil, thus providing for the perpetuation of the plant under conditions that are unfavorable for the taller growing forms. In the case of Grimm, F. C. I. No. 138 (Pl. VIII, fig. 1), which has true rhizomes, their function is twofold—that of protecting the buds from extreme cold by burying them several inches beneath the surface and of increasing quickly the area of the crown. Some plants of the Grimm variety which had true rhizomes have been found with crowns 2 feet in diameter. One of the principal functions of the large rhizome development of those varieties recently found in northern Africa may be the storage of water in their underground shoots to tide them over the very hot and dry summers, because the rhizomes of these plants in northern Africa are evidently formed at the close of the growing season, which is during the winter months, but when brought to a colder climate they form during the autumn months. The rhizomes are also instrumental in leaving a large amount of humus in the soil.

In some of the pronounced rhizome-bearing alfalfas taproots are not well developed, but it has invariably been noticed that those with poorly developed or small taproots have a very large number of rhizomes, which when fully developed send down roots of their own to a considerable depth the first season while still attached to the parent plant. Where this occurs the growing end of the rhizome develops branches above the surface. In favorable soil a single plant will cover several square feet of space in one season. Within this period a rooting rhizome has been observed to send down roots to a depth of 30 inches. The growth above ground on this rhizome is frequently as large as that of the original crown during the first season. (Pl. VI.)

DIFFERENT KINDS OF RHIZOMES.

Asa Gray defines the term "rhizome" as "A rootstock: A stem of rootlike appearance, prostrate on or under the ground, from which rootlets are sent off; the apex progressively sending up herbaceous stems or flowering stalks, and often leaves." The appearance of the rhizomes of the alfalfa during the first stages is, in all the forms noticed, of the same character; that is, they are of rapid development. The internodes are in most cases comparatively short, each one marked at regular intervals by rudiments of leaves and very large

stem-clasping stipular growths. (Pl. II, fig. 2.) When the growing points of these rhizomes approach the surface the stipular growths assume a reddish color and the leaves gradually assume the usual shape. Those rhizomes which are produced on plants, such as the Grimm and Turkestan, often branch out laterally before reaching the surface, but they seldom produce roots. However, they invariably start from the bases of the lower growths of the previous season. At each internode on the rhizome there is a dormant bud closely covered by the lower part of the stipular growth. These enable the plant, after occasional set-backs from unpropitious weather, to branch out from points well under ground. On other plants, such as those commonly found in northern Africa, the rhizomes will frequently travel 3½ feet by the middle of June before coming to the surface, and during their growth underground branching takes place to a greater extent than has been noticed on any other wild alfalfas; but the roots on these alfalfas are not well developed, at least they were not strongly rooted when examined about the middle of July. How they fare later in the season has not been ascertained, but the growths above ground at the period mentioned were not strong. The ground was exceedingly dry, and this would preclude the possibility of rank growth. The growth of this plant as seen under the intense heat and drought of African summers would be a most welcome sight in the semiarid parts of the United States. In some places this plant seemed to revel in what appeared to be almost pure sand.

ALFALFAS HAVING DEEP-SET CROWNS.

The deep-set crowns of alfalfas have been mentioned in several publications. A plant having this peculiarity attracted the attention of Thomas Le Blanc in England in the last half of the eighteenth century[1] and was found by him to be hardier than plants of *Medicago sativa*. Thus we have a very old record in which hybrid alfalfas with underground shoots were regarded as being hardier than ordinary *M. sativa*.

Brand and Waldron[2] found that at Dickinson, N. Dak., and at Stockton, Kans., the Mongolian alfalfa under very severe tests proved to be the hardiest of any of the newly imported strains, and in both places the crowns were more deeply set in the soil than other varieties. These authors say: "It seems likely that this adaptation, if it may be called an adaptation, is of importance in giving the tenderest part of the plant needed protection."

[1] Miller, Philip. Gardener's and Botanist's Dictionary, 1807.

[2] Brand, C. J., and Waldron, L. R. Cold Resistance of Alfalfa and Some Factors Influencing It. Bulletin 185, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1910, p. 68.

Olin[1] mentions a plant of the Grimm alfalfa and one descended from a plant known as South Dakota No. 167, which showed stooling qualities, but he does not mention this peculiarity as correlated with hardiness. The Grimm alfalfa plant, however, is stated to have had 10 per cent more stems than any other unit plant under study in the nursery.

Some of the wild alfalfas belonging to the rooting-rhizome section are very distinct from the bunching varieties, such as the Peruvian and allied forms, and also from those on the rhizomes of which no roots are formed. On examining a well-developed rhizome-forming plant for the first time one is apt to have but a vague idea of its nature, and it is sometimes probably regarded as a freak. This is not to be wondered at, since no well-defined allusions to rhizomes have been found in treatises on the alfalfas, and yet we meet with fairly numerous instances of rooting rhizomes among the strictly prostrate forms of *Medicago falcata*, once in the Grimm, and always in the forms of *M. sativa gaetula*, and to a limited extent in *M. sativa tunetana* and in one or two others which do not seem to have been described hitherto.

NONROOTING RHIZOMES.

At least three of the prostrate-growing alfalfas from the Caucasus region produce rhizomatic growths underground. During the two summers since planting, these rhizomatic growths have not produced roots. Like the plants which have rooting rhizomes, the underground growth is made during the autumn months from the bases of the previous summer's shoots. Some of the shoots are only about 3 inches in length and from that to 15 inches. Their growing points appear through the soil surface in early spring and in a short period thereafter a dense carpet of green is produced. This arrangement of the rhizomes is evidently a provision for their protection from severe frosts, as they are found growing at an elevation of 5,000 feet. The immature shoots are thus protected from pasturing animals. The rhizomatic growths in these alfalfas are invariably white in color and not much over one-sixteenth of an inch in diameter.

Numerous semirhizome-producing forms of *falcata-sativa* hybrids behave in a slightly different manner, but on the same general plan as those last mentioned, in that the young shoots for the following season's growth bury their growing points in the soil during autumn and remain buried during winter. In some plants they are not more than 1 inch in length and in others from 2 to 6 inches. Those forms which approach the latter size are usually branched (Pl. IX, fig. 1); the color of the rhizomes is purplish red, more pronounced on the stipular

[1] Olin, W. H. Establishing a Breed of Alfalfa for the Irrigated Lands of Colorado. American Breeders Magazine, vol. 2, no. 4, 1911, p. 284.

parts than on the stems. On the approach of favorable weather the growing points of the rhizomes are inclined toward the surface. Under the influence of light they change from purplish red to dull green, leaves following rapidly on the change of color. A peculiar feature of the rhizomes of this class is found in the very large stipules which sometimes cover a goodly section of the rhizome and which are developed to several times the size of the ordinary stipules (Pl. II, fig. 2). This arrangement of underground growth gives effective protection during winter and abundant space for the development of the shoots above ground.

The common forms of *Medicago sativa* when met with in a semi-wild state are seldom of such luxuriant growth as they are under good cultivation. As a consequence, the individual shoots are well developed and the bases are smaller and not crowded. It therefore seems that the plant which develops its growth by means of underground rhizomes, each pointing away from the crown, has the best chance of a long, healthy career in the field. So far as the development of the growth and the consequent longevity of the plant are concerned, it will also be likely to withstand severe winters much better than bunching forms, because the resting buds or partly developed rhizomes are usually protected by the bases of the old growths and commonly by from 1 to 3 inches of soil. It frequently happens in alfalfas having short nonrooting rhizomes that roots will be formed on the prostrate but ripened branches near the crown, as seen in Plate X, figure 1.

DIFFERENT SEASONS OF GROWTH FOR ABOVEGROUND AND UNDERGROUND STEMS.

The alfalfas of the *sativa* section, which includes the *sativa-falcata* hybrids with the rhizome-forming *falcata* characters predominating, seem to make but little growth above ground after the close of summer, except during wet spells, when the season for growth above ground is slightly prolonged. When, however, the underground growth begins, which it does during the fall, differing in the time of starting with the different varieties, the upper portion of the plant seems to make no progress whatever. All the energies of the plant are directed to the development of underground shoots, which from this period until the beginning of cold weather make very rapid growth.

VEGETATIVE PROPAGATION OF SELECTED PLANTS.

It is important that an individual alfalfa plant which is an artificial hybrid or one which has been selected from old strains and which has been bred to come true from seed should be raised quickly in large quantities. Raising seedlings from the original plant gives

only a limited number of plants the second season and so on till we find that several years elapse before there is enough seed to sow an acre of ground. In the same period that it takes to raise enough seed to sow an acre it is possible to raise a crop of seed from plants propagated from cuttings that will sow from 10 to 20 times that area. This is accomplished by asexual propagation, not by the division of the roots but by cuttings made from the growing stems above ground. The use of the seed method alone for several generations of increase from a single plant should be abandoned, not only because it is too slow, but because of the danger to which the plants are subjected each year through cross-pollination. Brand [1] unwittingly confuses two very distinct methods of vegetative propagation of individual alfalfa plants—that of propagation by cuttings of the shoots (Pl. VIII, fig. 2) and that of propagation by division of the crowns. It is possible within a year to raise plants from cuttings from a single individual of certain strains to cover more than a quarter of an acre of ground. On the other hand, by dividing a stooling plant—that is, cutting it into pieces—each piece having buds and roots attached, not over 50 plants at the most will be the outcome in the same space of time, and in the bunching plants only a very small number will result.

The method of vegetative propagation worked out by the writer a few years ago has been somewhat improved. When it is desired to grow a large number of plants from a single individual, so that a considerable quantity of seed may be obtained in a reasonably short period, this method may be used to advantage. The cuttings should be made as long as possible, so that several of the buds in the axils of the leaves will be under the ground. This obviously implies that in the rhizome-forming alfalfas branches will be produced from underground buds, thus building up a plant with the lower part of the crown buried in the soil. Cuttings for this purpose are made from 4 to 5 inches in length, all the leaves being removed except three or four at the growing end. The cuttings are quick to root when placed in clean sand. Cold frames and sash are necessary to keep the cuttings from wilting during the rooting process. After rooting they are hardened off, gradually removing the sash. The rooted cuttings can then be placed in a convenient receptacle and planted out in rows which are prepared beforehand. They may be planted with a dibble in much the same way that cabbage seedlings are planted.

ALFALFA CROSSES.

Many crosses were made during the summers of 1909 and 1910, principally to obtain an abundance of new forms so constituted as to thrive in areas where the common alfalfa does not succeed, and possi-

[1] Brand, C. J. Peruvian Alfalfa: A New Long-Season Variety for the Southwest. Bulletin 118, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1907, p. 27.

bly to shed some light on the parentage of certain strains now growing in different parts of the country. Of some of those which were crossed in 1910 many of the seeds germinated too late in the summer of 1911 to give flowers. However, several plants of each cross flowered and fruited sufficiently to show the nature of the hybrid progeny.

A few of the principal features of the parents and hybrid plants are given in the necessarily brief descriptions of the individuals of each first-generation cross. It should be borne in mind that the descriptions of the individual plants cover only the first summer's growth above ground and also the autumn period when the underground shoots are formed.

It is a very easy matter to raise a hybrid alfalfa, but if it is raised according to the easy way it is worse than useless. The common bumblebee in five minutes will do the work necessary to raise a dozen hybrids, but these hybrids will be trouble mongers. As a rule, only one of the parents is known, which is not sufficient.

To prosecute the work of crossing alfalfas faithfully entails much tedious preliminary work, especially that part which is absolutely necessary, the selection of pure parents. This in itself necessitates self-pollination of their flowers to ascertain whether their progeny comes true to the type selected. If this is not attended to, the operator will often get a hybrid, or at least a seedling likely to be mistaken for a hybrid, which is merely a plant in which expression is given to recessive characters in the parent plants.

THE DEVELOPMENT OF FIRST-GENERATION SEEDLINGS.

The hybrid progeny resulting from mating two plants each of which has been bred to reproduce true to its own pollen can be depended upon to be intermediate between the parents selected.

This hybrid progeny of the first generation must be self-pollinated and the seeds sown. The seedlings will consist of a large number of varying forms, giving as large a variation as we get in second-generation crosses of the cowpea. All of the varying forms should be subjected to a test for hardiness, which will probably result in a considerable proportion being victims of low temperatures. Individual selections should then be made from the plants which come closest to the ideals of the experimenter. From 10 to 20 plants will be sufficient. The flowers on each plant are again to be self-pollinated and about 100 plants raised from the seeds of each individual. There will be comparatively little variation in the progeny from each second-generation plant in this generation, and the most that can be done is to select those individuals that are similar in every way to the selected plants of the second generation, discarding the

others. The next generation of plants raised from seeds resulting from self-pollinated flowers will give plants that as a rule can be depended upon to come true from seeds, provided that pollen from other strains is excluded. This is the great difficulty to overcome, and its solution is not an easy one. Isolation from other strains is the only practicable way of solving the difficulty. Just how far they should be grown from other strains to preclude the possibility of insects carrying undesirable pollen to the flowers has not yet been determined.

The method of raising new alfalfas was up to a few years ago solely through the agency of insect visitations. It was the only one available and, unfortunately, it is still used, though not to the same extent as formerly. The bumblebee is not discriminating. It may or it may not bring the desired kind of pollen to the stigmas of the flowers of the proposed seed plant, and seeds gathered from them will probably result in many dissimilar plants, to the bewilderment of the experimenters.

THE TEST OF THE METHOD OF PREPARING FLOWERS FOR CROSSING.

The successful depollination of alfalfa flowers and those of other plants of this family previous to applying foreign pollen to the stigmas may be ascertained by a very easy method and will show the beginner whether the work has been done well or otherwise. It is a test which should be tried by everyone engaged in this line of work.

Select 100 flowers and depollinate by a jet of water, as explained in a recent bulletin of the Bureau of Plant Industry.[1] Allow the stigma to assume its natural position on the banner of the flower, but without the application of pollen to the stigmas. If no seed is produced, then it may be assumed that the depollination was thorough in each case. In the application of water to the stigmas different periods of time may be given four series of 25 flowers each, training the jet of water on the first 25 flowers for a period of 5 seconds, on the next 10 seconds, and on the third and fourth series 15 and 20 seconds, respectively; label each series and note the results, which will serve as a guide for thorough depollination.

THE SOWING OF THE HYBRID SEED.

As a result of crossing the flowers of any two plants it very frequently happens that but a small number of seeds is secured. In order to get as high a percentage in germination as possible, it is

[1] Oliver, G. W. New Methods of Plant Breeding. Bulletin 167, Bureau of Plant Industry, U. S. Dept. of Agriculture. 1910.

necessary to provide the best conditions, so that every seed will have an opportunity to sprout. This part of the work is just as important and requires as much skill as the actual work of crossing. With alfalfa seed sown shortly after ripening the best results have been obtained with pure sand, covering to a depth of five-eighths of an inch. The receptacles for the soil should be 6-inch flowerpots. If sown in flats, the seeds should be 1½ inches apart in the row and the rows the same distance apart. The reason for wide spacing is that the seeds do not all germinate at the same time; there may be a difference of two to three months between the appearance of the first and last seedlings of a few seeds secured from cross-pollinated flowers. Therefore, the wide spacing gives an opportunity to remove and pot a seedling which appears quickly, without displacing the other seeds. The space from which a seedling has been removed should be marked with a toothpick and the vacant spaces in a partly seeded row should be similarly indicated. It has happened that seeds will lie in the soil for many months without germinating, even under favorable conditions so far as temperature and moisture are concerned. These seeds should be carefully taken up, rubbed gently between two pieces of sandpaper, and resown in pure sand. They will, as a rule, germinate in a day or two, and as soon as the cotyledons reach full size they may be pricked off around the edge of a 6-inch flowerpot.

PLANTS WITH A POOR POLLEN SUPPLY.

There is abundant evidence to show that the anthers of the flowers of some *Medicago falcata* plants are in many cases either devoid of pollen grains or at most have a very limited supply. The variety of *M. falcata* known as S. P. I. No. 20721 is an example of the latter condition. Insects visiting flowers of *M. falcata* seem to be seldom successful in effecting pollination, as very few flowers on any one plant set seed. During the summers of 1910 and 1911 a large plant of the above serial number did not produce a single pod; it was isolated from other alfalfas, but insects had access to it at all times. It would seem from the correspondence of the Bureau of Plant Industry with observers in the *M. falcata* regions that most forms of this species are more or less shy seeders. There are forms of *M. falcata*, however, which are abundant seed producers and, strange to say, they seem to have pods of the nonshattering form.

THE DEVELOPMENT OF SEEDLING ALFALFAS.

The manner of the development of growth from the cotyledon stage in spring to the end of the first season or the beginning of cold weather is exceedingly interesting, especially when studied in connection with those hybrids which produce rooting rhizomes.

It is somewhat remarkable to find that the rhizome-forming growth of most plants has its origin in the axils of the seed leaves. Plate VII, figure 2, shows this gradual growth from a seedling in the cotyledon stage to the development of a plant 6 weeks old. Plate VII, figure 2, *A* and *B*, shows a seedling with the cotyledons and one with the first foliage leaf. The subsequent growth of the first shoot above the seed leaves is only a few inches, because its function is to keep at work just long enough to enable the buds on the lower part of the shoot to develop. The seedling at *D* (Pl. VII, fig. 2) shows a bud perfected in the axil of one of the cotyledons before their decay. This seldom happens, because the seed leaves immediately before this stage are little more than breathing surface and keep the plantlet alive, so that the roots and true leaves will be able to take care of themselves. The first lateral growth is usually seen sprouting from the axil of the leaf, with a single blade. Another shoot develops in the axil of the leaf immediately above it. These two shoots make considerable growth, depending upon the variety or species. In this case it is the intention to show merely the beginning of the rhizomatic growth, which develops fully when the seedlings are less than a year old. Plate VII, figure 2, *E*, shows the beginning of the development of the rhizome. These two growths are from the axils of the cotyledons, being formed before their decay. At this stage they necessarily are in a very immature state. Plate VII, figure 1, shows their condition several weeks later. They are then quite large and easily distinguished from the growths above.

It would seem that the main root contracts considerably, or at least sufficiently to enable the part originally occupied by the cotyledons to be drawn below the surface of the soil, because some simple experiments conducted with the object of ascertaining why the neck of the plant is sometimes deep in the soil suggested no other explanation than the contractile nature of the roots.

Out of many thousands of seedlings examined only a single instance has been found where zhizomes were developed below the part originally occupied by the seed leaves. This very remarkable growth occurred in one of the seedlings of cross No. 284, Plate X, figure 2, which shows two rhizomes developing fully 3 inches below the point occupied by the cotyledons. However, when seedling crosses where one of the parents has rhizomes are carefully planted out with the portions occupied by the seed leaves exactly level with the surrounding soil it has almost invariably happened that within six months those parts of the stems formerly occupied by the cotyledons are from 2 to 3 inches below their former levels, while some allowance must be made for the firming of the soil due to beating rains and to other causes.

Those plants which are drawn down into the soil are commonly of the rhizome-producing types. The rhizomes may be anywhere from 3 or 4 inches to 3½ feet in length.

The alfalfa plants which are drawn down into the soil form a considerable proportion of the individuals of the Grimm, Turkestan, Baltic, and Mongolian varieties. These conclusions are drawn from many hundreds of seedlings from hardy strains sent to the writer by Prof. W. A. Wheeler, of Mitchell, S. Dak.

DESCRIPTIONS OF CROSSES.

CROSS NO. 191 (MEDICAGO FALCATA, S. P. I. NO. 20721 ♀ × M. SATIVA, S. P. I. NO. 17698 ♂).

The seed-bearing parent, *Medicago falcata* (S. P. I. No. 20721), is one of the tallest of this species. It has been grown on the Department grounds for three seasons. During the first summer it attained a height of 2½ feet, the second season 3½ feet, and during the summer of 1911 it reached a height of 4½ feet. It is a semi-upright plant and belongs to that section of *M. falcata* the plants of which are almost or entirely without rhizomes. The large dormant buds, however, are under the surface of the soil. Late in the season it produces a dense crop of very short growths not over 3 inches in length. The stems of these shoots are not thicker than a pin and the leaves are very small. If this is a normal growth, it would seem to function in the protection of the crown during winter. The root of this plant is the largest of any seen by the writer. In digging to ascertain the depth to which it descends, the task had to be abandoned, because at 8 feet below the surface the roots were still quite large. They probably descend to a depth of over 20 feet.

The pollen-bearing parent is a hardy form of *Medicago sativa* (S. P. I. No. 17698) from Chinook, Mont. It is a bushy upright plant, but it is evidently not a typical *M. sativa*, because seedlings raised from inbred seed showed unmistakable characters indicating that it has a small percentage of *M. falcata* blood in it.

Cross No. 191 is one of the few crosses of which the first-generation plants were invariably alike. From a close scrutiny of the 16 plants raised it was impossible to detect any variation. This is owing to the fact that both parents do not vary from inbred seed, as subsequently proved. Before the flowering period, the 16 plants looked as if they might have been typical *M. sativa;* in fact, it was thought that a mistake had been made. However, when the first flowers opened, this supposition was dispelled. The flower colors of the plants were invariably alike and they resembled the color of the foliage to such an extent that the plants had to be examined closely to find all the flowers. Before and during the flowering period the

first-generation plants were kept in a large wire cage to prevent the flowers being cross-pollinated by insects. The flowers were then tripped by hand and a generous supply of seeds secured.

The second-generation plants were raised during the winter of 1910–11. The progeny of each of the plants of the first generation were kept separate. In this generation the colors of the flowers varied exactly as was expected, ranging from the color of *Medicago falcata* to that of the *M. sativa* parent. The plants of both generations resemble the pollen parent to a much greater degree than the seed parent in so far as habit and foliage are concerned. The general appearance of the flowers and fruit of the parent plants and also those of the first-generation cross is shown in Plate XI, figure 1.

Owing to the numerous progeny of the second generation, the flowers could not be given the same careful treatment to insure self-pollination which was accorded to those of the first generation. However, they were grown in a cool greenhouse and carefully tripped by hand.

The pods of the second generation vary from about two-thirds of a turn to about two turns.

A very noticeable feature in over two-thirds of the progeny of the second generation is the disposition of the plants to form short underground nonrooting rhizomes in autumn immediately after the cessation of top growth. In some of the plants this character is much more accentuated than in others. The plant of *Medicago sativa* from Montana (S. P. I. No. 17698) does not show this character to such a degree as do the hybrid progeny and in the *falcata* parent it is observable only to a very slight degree. It is nevertheless fortunate that the larger number of the second-generation plants have this character, as it obviously means better equipment for northern latitudes. These underground growths are all from the bases of the shoots of the previous summer. They make a horizontal growth of 2 to 3 inches and remain under ground during winter ready to branch out at the surface on the approach of spring. These underground branches even when their tips are within less than half an inch of the surface of the soil do not seem to be injured during cold weather. Some of the plants in large pots have been exposed all winter without any covering and escaped injury although the temperature fell to —13° F. on one or two occasions. With the branches 3 inches below the surface, under good field conditions they will probably stand the lowest possible temperatures of the Northern States. The pollen-bearing *M. sativa* parent from Montana did not have underground growths, but the plant was grown in a large pot in firm soil. Consequently it did not get an opportunity to develop as it would have done had it been planted in the field. The seed-

bearing parent is only fairly well supplied with underground buds, but those examined showed they were not true rhizomes. Perhaps the short rhizomes in the hybrid progeny are due to a latent character in one of the parents. The growth of every one of both the first and second generation plants does not in the least resemble that of the *M. falcata* parent in the development above ground either in the leaf blades or stipules, but the flower color in the first generation is uniformly intermediate between the colors of the flowers of the two parents, and in the second-generation plants the colors range from that of the seed parent through the intermediate shades to that of the pollen parent.

This and other crosses show that if we take an inbred plant of one of the standard varieties of *Medicago sativa* and cross it with all of the many different forms of *M. falcata*, including those with straight and falcate pods, smooth and hairy, upright, decumbent, and prostrate in habit, we will get the basic forms of practically all of the varieties comprising the very numerous and divergent forms common at the present time, which undoubtedly descended from hybrids and which now pass as mere forms of *M. sativa*.

While many crosses raised from the various forms of *Medicago falcata* and *M. sativa* are more or less decumbent, some of the plants of cross No. 191 are upright and very different from the plants of crosses in which other forms of *M. falcata* take a part. From this we must come to the conclusion that the characters of the various forms of *M. falcata* should be carefully studied before the plants are used when upright-growing progeny are wanted. According to the experience gained during the last few years, a dwarf straggling form of *M. falcata* used either as the male or female in a cross will not produce upright progeny, but a plant of *M. falcata* having an almost upright habit, when crossed with an upright *M. sativa*, will give progeny a little less erect than *M. sativa*, but much more erect than the *M. falcata* parent.

CROSS NO. 284 (GRIMM, F. C. I. NO. 138 ♀ × S. P. I. NO. 28042 ♂).

The pollen-bearing parent of this cross is S. P. I. No. 28042, a large-leaved prostrate plant thought to be *Medicago sativa gaetula*, from the Caucasus Mountains at an altitude of about 4,000 feet. This plant has long rooting rhizomes. The seed parent is a Grimm alfalfa, F. C. I. No. 138 (Pl. VIII, fig. 1), which is possibly one of the few plants of this partly hardy strain which has short rooting rhizomes. It represents what is probably the hardiest of this strain and was selected for breeding, not so much because it was a Grimm alfalfa, but because it was one of the first plants noticed by the writer to have the resting buds several inches beneath the surface of

the soil. This Grimm alfalfa plant has undoubtedly descended from an old strain which originally had the rhizome character much more developed and probably was originally a cross between a *M. sativa* and a semiprostrate rhizome-producing form of *M. falcata*. However, the Grimm alfalfa (F. C. I. No. 138) is possibly a seedling from a very old plant and perhaps one of the original plants resulting from the seed sown in Minnesota which is said to have been brought from Germany in 1857.[1] There seems to be some doubt as to the identity of the pollen-bearing parent, as a description of it does not exactly agree with that of any published species or variety. It seems an intermediate form between *Medicago glandulosa* and *Medicago sativa gaetula*. The flowers are light purple with the exception of the keel, which appears to be light yellow while the flower remains untripped, probably owing to the partly transparent nature of the keel, allowing the color of the stamens to be seen. The pods are much larger than those of *M. sativa* and are densely studded with glandular hairs. The plant is only about 6 inches in height, and during the summer a seedling plant will cover about 4 square feet. The rhizomes are abundant, pure white, and produced in October and the first part of November at Washington, D. C. They push their way to the surface in April, and after leaves are formed they produce roots. The shorter rhizomes come to the surface near the crown, the longer ones appearing farther from the center of the seed-bearing plant.

The plants of the first generation which have flowered, 44 in number, are all hybrids, shown by the fact that the pods have glandular-haired pubescence, resembling in this particular the pollen-bearing parent, while the pods of the parent Grimm alfalfa are smooth. The flower color of the hybrid plants resembles that of the pollen parent. The height of the stems of the tallest plants is about 24 inches, ranging from that to about 15 inches, but consideration must be given to the fact that the plants were set out from 4-inch pots about the middle of May and after ripening a comparatively small number of pods their energies seem to have been spent on the development of an enormous quantity of underground rhizomes. Plate X, figure 2, shows a seedling which began to form rhizomes when only a few weeks from the germinating stage. By the beginning of August some of these rhizomes had well-developed roots with considerable growth above ground. By the end of October the tremendous rhizome formation had ceased and the plant thus assumed its winter stage. (Pl. VI.)

[1] Westgate, J. M. Variegated Alfalfa. Bulletin 169, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1910, p. 21.

This plant far surpasses any other wild or cultivated plant so far observed by the writer in the production of rooting rhizomes. Many of these underground growths are from 2½ to 3 feet in length. The other plants of the same parentage, so far as the development of the underground rhizomes is concerned, have some rhizomes branching to a greater degree than the one mentioned, but they are not quite so long. There is every indication that these plants will cover a larger space than any of the others, either of hybrid origin or otherwise, and owing to the resting buds being very deep in the ground they will probably be very hardy. It is intended to try these and other individuals of the same cross over a wide range of territory as soon as practicable after they have been developed at Washington, D. C., to the third generation, which will take at least two years more to accomplish.

CROSS NO. 289 (GRIMM, F. C. I. NO. 131 ♀ × MEDICAGO SATIVA GAETULA, S. P. I. NO. 26590 ♂).

The Grimm alfalfa used as the seed bearer in this cross is quite unlike F. C. I. No. 138 in that it has no rooting rhizomes, but the plant is so deep in the soil that the shoots situated at the lower part of the crown are covered to a depth of from 2½ to 3 inches. It is thus protected during very low temperatures. It was selected by Mr. Westgate from a field of the Grimm alfalfa on Mr. Ensler's farm near Excelsior, Minn., and was chosen by the writer for crossing because of its deep crowns, upright growth, height, and leafiness. *Medicago sativa gaetula* (S. P. I. No. 26590), the pollen-bearing parent, is from Algeria. This plant is probably quite hardy, but of this we have no direct proof, as it seemingly has never been tried in excessively cold regions. It has a very vigorous lot of rhizomes, which are developed early in autumn. These rhizomes are deeply buried in the soil.

From the appearance of the plant in summer one would not imagine it to be a good hay-producing type. However, it promises to be a good plant to grow in light sandy soils in regions where the annual rainfall is light. From the hundreds of resting buds deep in the soil it would seem that it would be unaffected by drought or extreme cold. In the semiarid parts of the country it will probably grow better than any other alfalfa. This supposition is based entirely on its exceedingly long underground rhizomes deep in the ground. These very numerous rhizomes terminate in shoots above ground and eventually produce strong roots. Another good feature is the large number of resting buds at short intervals along the entire length of the rhizomes.

The pods of *Medicago sativa gaetula* are thickly studded with glandular hairs. The flower color is bluish purple tinged with yellow.

Plant No. 289–3.—Flowers greenish purple, yellow keels; glandular-haired fruit; foliage bluish green; crowns deep in the soil; short rooting rhizomes. These rhizomes were formed before the plant was 6 months old. Stems and leaves without hairs. Growth made during the first summer, about 18 inches in height.

Plant No. 289–4.—Flowers greenish purple; glandular-haired pods; erect habit. The numerous rhizomes were 8 inches long by the beginning of November. Rhizomes begin to send down roots in early spring. Leaves and stems slightly hairy. Growth made during the first summer, 19 inches in height.

Plant No. 289–5.—Flowers greenish purple, yellow keels; glandular-haired fruit; foliage bright green; leaves and stems smooth; rhizomes resembling those of the pollen parent in length, but stouter, sending down long roots; growth made during the first season, about 1 foot; scant vegetation above ground, evidently due to enormous rhizome development.

CROSS NO. 293 (GRIMM, F. C. I. NO. 131 ♀ × MEDICAGO FALCATA, S. P. I. NO. 24455 ♂).

The plants of this cross promise to be very cold resistant, as the seed bearer, Grimm alfalfa, was secured from seed gathered from a plant known to be hardy in North Dakota, the flowers of which were self-pollinated; nearly all of the seedlings resemble this plant, especially in their equipment to stand very cold weather.

The pollen-bearing parent is S. P. I. No. 24455, a form of *Medicago falcata* found by Prof. Hansen north of Semipalatinsk, western Siberia. It is stated that plants of this form were found with stems 5 feet 8 inches long.[1]

Plant No. 293–1.—The flowers of this plant are greenish purple; stems 20 inches tall; slightly decumbent; no underground rhizomes present, but there are numerous short shoots at the bases of the summer's growths. The crown is low down in the soil.

Plant No. 293–3.—Flowers greenish purple; crown deeply set in the soil; goodly supply of stout, short branching rhizomes, which in October point downward in the soil; stems and leaves smooth; height, 18 inches.

Plant No. 293–5.—Flowers greenish purple; very stout branching rhizomes. During summer the bases of the shoots produced numerous roots when the plants were 5 months old. Height of growth, 20 inches; stems and leaves smooth; promises to form very large crowns.

[1] Willis, C., and Bopp, J. B. Progress in Variety Tests of Alfalfas. Bulletin 20, South Dakota Agricultural Experiment Station, Brookings, S. Dak.

CROSS NO. 294 (GRIMM, F. C. I. NO. 131 ♀ × S. P. I. NO. 28042, PLANT NO. 6 ♂).

The Grimm alfalfa seed bearer in this cross is the same as used in cross No. 293 The pollen-bearing plant was found in the Caucasus region at an elevation of 4,000 feet and is therefore assumed to be hardy. If the depth of the rooting rhizomes of wild plants is an indication of the hardiness of a plant, this ought to be an exceptionally hardy strain and probably also drought resistant.

Plant No. 294–1.—Flowers very light purple, with yellow keels. Fruits profusely covered with glandular pubescence; crowns deeply set in the soil; growth 18 inches tall; upright; no rhizomes; branches of crown rooting at a point from 1 to 2 inches above top of taproot.

Plant No. 294–2.—Flowers light purple, keel yellow; pods large, with glandular hairs; free seeding; no rhizomes; crown of plant low down in the soil.

Plant No. 294–3.—Flowers purple, keel yellow; glandular hairs on fruit; height of plant 18 inches; stems and leaves smooth; very heavy crop of rhizomes, all of them very stout and much branched; some of the most advanced in growth produced roots before the advent of cool weather.

Plant No. 294–4.—Flowers light purple, not changing in color; pods with glandular hairs; plant erect; height of growth the first season 18 inches; very thick branching rhizomes starting at a point 3 inches beneath surface of soil.

CROSS NO. 295 (GRIMM, F. C. I. NO. 131 ♀ × MEDICAGO FALCATA, S. P. I. NO. 24455 ♂).

For description of parents, see cross No. 293.

Plant No. 295–1.—Flowers almost yellow, faintly shaded with purple; very short rhizomes; crown deeply set in soil. The rhizomes begin from a point 4 inches below the surface. Height 20 inches. A promising plant.

Plant No. 295–3.—Flowers almost yellow, faintly purple on opening, changing to green with age; rhizomes very short, but forming roots and tops the first season; crown 8 inches in diameter when seven months from the seedling stage. A promising hardy form.

Plant No. 295–4.—Flowers yellow, faintly purple on opening, changing to purplish green; of upright growth; 20 inches in height during first season; leaves and stems smooth; crown deeply set in soil; strong rhizomes formed in October from a point 4 inches below surface of soil. A promising hardy form.

CROSS NO. 299 (PERUVIAN, G. AND G. NO. 60 ♀ × S. P. I. NO. 28042 ♂).

The seed-bearing parent of cross No. 299 is a typical Peruvian alfalfa from Yuma, Ariz. (Pl. V, fig. 2.) This variety is characterized by a strong upright growth and hairy stems and leaves. The

crown of the plant is usually at or very near the surface of the soil. It is a comparatively tender strain, although it has withstood the cold of several mild winters at Washington, D. C. It has been shown to be capable of withstanding a lower temperature during the development of growth at Yuma, Ariz., than any other variety.[1] The very hairy stems and leaves in all probability have something to do with its ability to stand low temperatures when growing.

The pollen-bearing parent, S. P. I. No. 28042, is a dwarf-growing plant from the Caucasus region at an elevation of 4,000 feet. It has bicolored flowers. The banner and wings are light purple and the keel is yellowish. The pods are almost as large as the variety of *Medicago sativa* known as *tunetana*. The pods also resemble those of *M. sativa tunetana* in that they have glandular hairs.

Plant No. 299–1.—Flowers very light purple, yellowish keel; pods with glandular pubescence; height of growth during first season 24 inches; young stems purplish; leaves and stems hairy, plainly showing the blood of the Peruvian variety. The transmitted male characters are noticeable in the yellowish keel of the flower and the very thick and long rooting rhizomes. Growth upright, strong. The rhizomes averaged about 15 inches in length by the end of October, making a crown over 2 feet 6 inches in a single summer. This plant promises to form a very much larger crown in a short period. It will possibly be much hardier than the typical Peruvian variety. It seems peculiarly well suited for growing in warm areas where irrigation is lacking, but it remains to be seen just how this alfalfa will behave in the field, as the profusely developed underground rooting rhizomes are exceedingly robust. There is no doubt that the blending of these two plants will result in a strain to outward appearances somewhat like the Peruvian, but with thoroughly protected underground parts.

There are 26 other plants of this cross, the seeds of which germinated late in the season and which have not bloomed, but their characters so far indicate that they are more or less like plant No. 299–1.

CROSS NO. 300 (PERUVIAN, G. AND G. NO. 60 ♀ × MEDICAGO FALCATA, S. P. I. NO 24455 ♂).

The seed bearer, No. 60, is a typical Peruvian from the original plants which withstood several winters at Washington, D. C. It is not provided with underground rhizomes and the resting buds are fully exposed during the winter. As it is a strictly upright and tall-growing form, it was selected for crossing with one of the very hardy

[1] Brand, C. J. Peruvian Alfalfa: A New Long-Season Variety for the Southwest. Bulletin 118, Bureau of Plant Industry, U. S. Dept. of Agriculture. 1907.

forms of *Medicago falcata* (S. P. I. No. 24455, Pl. X, fig. 1) brought by Prof. Hansen from a district in Siberia where the mercury is said to freeze in the thermometers with no snow on the ground.[1] This form of *M. falcata* is comparatively low growing at Washington, D. C. It was planted alongside S. P. I. No. 20721. Its greatest height in two years amounted to only about 12 inches. The broad crown of the plant is deep in the soil, and numerous but very short growths are made in the autumn from the lowest buds. It was crossed on Peruvian to ascertain the result of a union between one of the tenderest and one of the hardiest of the alfalfas.

Plant No. 300–1.—Flower, greenish purple with slight traces of yellow; stems and leaves hairy. This plant has the crown exposed above the surface of the soil, showing the character of Peruvian alfalfa in this respect. No rhizomes; height 24 inches.

Plant No. 300–5.—Greenish yellow flowers; stipules not fringed at base. Although Peruvian alfalfa was the seed plant, there is no trace of it in the stems and leaves of this first-generation plant, it being absolutely without hairs, both on stems and leaves. This plant was put out too late to flower. It produces roots in abundance from the bases of the shoots during September. Seemingly a large-crowned form.

CROSS NO. 309 (S. P. I. NO. 28042 ♀ × F. C. I. NO. 131 ♂).

S. P. I. No. 28042 has already been described in former crosses.

Grimm, F. C. I. No. 131, was selected for its deep-rooting crown, the base of which was nearly 3 inches below the surface of the soil.

Plant No. 309–3.—The only plant which has flowered so far has light-purple and yellow flowers and glandular-haired pods. It is a semiprostrate form, very abundantly supplied with much-branched underground rooting rhizomes. (Pl. IX, fig. 2.) It promises well for intermountain areas. Out of the cross there are 13 plants which have not yet flowered. All of them have comparatively small round leaflets.

CROSS NO. 318 (GRIMM, F. C. I. NO. 269 ♀ × S. P. I. NO. 28042 ♂).

The Grimm parent of this cross is a second-generation seedling of F. C. I. No. 138, which has its resting buds deep in the soil. It was selected by the Office of Forage-Crop Investigations on account of extreme hardiness and number of stems. The pollen parent is S. P. I. No. 28042, which has been described in some of the foregoing crosses.

Plant No. 318–1.—Rose-purple flowers; pods with glandular hairs.

[1] Hansen, N. E. The Wild Alfalfas and Clovers of Siberia, with a Perspective View of the Alfalfas of the World. Bulletin 150, Bureau of Plant Industry, U. S. Dept. of Agriculture. 1909.

The crown of this plant is well protected by being from 2½ to 3 inches deep in the soil. Roots are developed from the bases of branches during the first season. (Pl. I, fig. 2.)

Plant No. 318–2.—Not yet flowered; rhizomes poorly developed; stems and leaves smooth; well protected by deep-rooted crowns.

Plant No. 318–3.—Light-purple flowers; pods with glandular hairs; strong rooting rhizomes; medium-good upright growth. The plant has a deeply seated crown.

Plant No. 318–4.—Greenish purple flowers; glandular-haired pods; long, creeping rhizomes well under the ground, the best plant of the cross in this respect. Plant upright in growth.

Plant No. 318–5.—Very light purple flowers; glandular-haired pods; stems almost smooth; dwarf, bushy; no rhizomes.

Plant No. 318–6.—Light-purple flowers; glandular-haired pods; a bushy, upright plant with a few short rhizomes.

Plant No. 318–8.—Flowers very light purple and yellow; glandular-haired pods; plant strictly upright, 18 inches tall, stems and leaves slightly hairy. This plant has the base of the crown at the surface.

CROSS NO. 320 (S. P. I. NO. 28042 ♀ × PERUVIAN, G. AND G. NO. 60 ♂).

This is very decidedly an instance in which some of the principal characters of the male parent preponderate over those of the female in the first-generation plants.

S. P. I. No. 28042, the seed bearer of the above cross, has glandular-haired pods and a more or less procumbent habit, with a generous supply of underground rooting rhizomes. The flowers are large, light purple in color except the keel, which has a yellowish cast. This plant was collected between Dushet and Passanaura, Caucasus, Russia, at an altitude of 4,000 feet. It bloomed in June, 1910. Pollen from No. 60, a Peruvian plant, was applied to the stigmas of the glandular-haired plant. During the first few months after the resulting seeds germinated the growth of the hybrid progeny so closely resembled the pollen parent that at first the writer thought that a mistake had been made and that the seedlings were of the typical Peruvian alfalfa. The appearance of the flowers, however, dispelled this belief, because they resembled the color of those of the female parent. As the fruit approached maturity they were found to be thickly studded with glandular hairs, which is another character of the seed-bearing parent.

As the resting period approached, the plants developed numerous and very strong underground rhizomes. Thus it will be seen that three of the important characters were transmitted by the seed bearer to the hybrid progeny, viz, the glandular hairs, flower color, and

rhizome development, while the pollen-bearing parent[1] transmitted upright stems, which, together with the leaves, are quite hairy and have a remarkable likeness to the Peruvian alfalfa.

It will be interesting to ascertain to what extent the male has transmitted its hardy nature to the hybrid progeny, as the underground parts of the plants are evidently perfectly equipped to withstand winters of a much more searching nature than the conditions prevailing where the Peruvian alfalfa succeeds best.[2] Very large branching underground rhizomes have been formed low down below the crowns of some of the plants. Other plants have unbranched rhizomes. These rhizomes seem to function in insuring a liberal supply of shoots at the commencement of the growing season. However, it is yet too early to judge of their nature in this respect. There can be no doubt, however, that these plants will each cover a considerable area of ground in one or two seasons.

Plant No. 320–1.—Stems upright; 3 feet in height; color of flowers light lavender; glandular-haired pods; no rhizomes. The crowns are deeply situated in the soil.

Plant No. 320–3.—Stems and leaves hairy; very large rooting rhizomes; crowns 8 inches in diameter at end of first season; pods with glandular hairs.

CROSS NO. 321 (GRIMM, F. C. I. NO. 135 ♀ × S. P. I. NO. 28042 ♂).

The seed-bearing parent is a plant which has the crown deep in the soil. A 1-year-old plant develops a crown about 8 inches across. Some of the principal divisions of the crown develop fairly large roots. S. P. I. No. 28042 is a plant with very abundant rooting rhizomes and prostrate habit.

Plant No. 321–1.—The Grimm parent is not an inbred plant; consequently the hybrid progeny has no resemblance to it. Its appearance is more like that of a Turkestan variety. The pollen-bearing plant has transmitted its rhizome-forming character and large glandular-haired pods.

CROSS NO. 322 (GRIMM, F. C. I. NO. 135 ♀ × S. P. I. NO. 28041 ♂).

The Grimm is the same plant used as seed bearer in cross No. 321.

S. P. I. No. 28041 is a semiprostrate plant found in the Caucasus Mountains. The flowers are very dark blue and very small. The pods are smaller than those of *Medicago cancellata* and quite black

[1] This plant is from a rooted cutting from the individual plant of the Peruvian alfalfa from which pollen was taken in raising the first alfalfa hybrid by the now generally adopted method described in Bulletin 167, Bureau of Plant Industry, U. S. Dept. of Agriculture, entitled "New Methods of Plant Breeding." 1910.

[2] Brand, C. J. Peruvian Alfalfa, a New Long-Season Variety for the Southwest. Bulletin 118, Bureau of Plant Industry, U. S. Dept. of Agriculture. 1907.

in color. The plant is provided with a large number of long rooting rhizomes.

Plant No. 322–2.—All of the plants in this cross germinated late and did not flower in 1911. All of them have growth very much resembling that of *Medicago lupulina* above ground. Rhizomes fairly well developed under ground.

CROSS NO. 323 (S. P. I. NO. 25733 ♀ × S. P. I. NO. 28041 ♂).

S. P. I. No. 25733, the seed-bearing parent, is a form of *Medicago sativa* from Bridgeport, Kans.

S. P. I. No. 28041 is the same plant used as the pollen bearer in Cross No. 322.

Plant No. 323–1.—Flowers purple; glandular hairy pods; plant procumbent in habit; short rhizomes; crown deeply seated.

Plant No. 323–2.—Flowers purple; glandular hairy pods; leaves and stems smooth; growth straggling; supplied with a large number of short rooting rhizomes; height 18 inches; crown deeply seated.

Plant No. 323–3.—Flowers bluish purple; stems and leaves smooth; crown deeply set in soil.

Plant No. 323–4.—Not in flower; crown 2 inches below the surface; stems and leaves resembling those of Peruvian alfalfa; height of growth first season, 2 feet.

CROSS NO. 336 (S. P. I. NO. 26667 ♀ × S. P. I. NO. 26865 ♂).

The seed bearer, S. P. I. No. 26667, is a dwarf form of *Medicago falcata* from the Crimea, with straight smooth pods and light-yellow flowers. It is provided with a fair number of rhizomes near the surface of the ground. (Pl. IV, fig. 2.) The pollen-bearing parent, S. P. I. No. 26865, is from the Caucasus region and is a taller growing form of *M. falcata*, with straight hairy pods. The growth above ground is somewhat sparse, owing to the specimen received being small, but the new rhizomes are very abundant. The cross was made to ascertain whether a hybrid could be secured which could be used as a reliable pasture plant; that is, an alfalfa with short, dense growth and an abundant supply of underground rooting rhizomes. Some of the progeny are exceedingly promising. (Pl. III, fig. 1.)

Plants Nos. 336–1–32.—About 5 inches in height. The leaves are short and smooth, very close together on the stems, and bluish green in color. Most of the rhizome-forming alfalfas produce the principal crop of rhizomes in the autumn or late summer. This plant seems to stop growing only when the ground is frozen hard. It is also the first alfalfa to begin growing, as it is quite green in March. It produces rhizomes throughout the growing season. It looks exceedingly promising as a pasture plant because when shorn of all the stems and

foliage above ground and down to a depth of 1 inch beneath the surface it soon recuperates and throws up numerous growths in a few days. The rhizomes are different from those of any other alfalfa noticed by the writer in that they send out roots along their entire length (Pl. III, fig. 2). Some of them have measured 3 feet in length. Rhizomes formed from the seedlings planted out in the summer of 1910 were found in the autumn of 1911 to have pierced the soil to a depth of over 12 inches. Plate III, figure 2, shows two pieces of rhizomes found at this distance below the surface. New rhizomes are seen sprouting from the old ones, proving that dormant buds deep in the soil are ever ready to send up new rhizomes to the surface. Each rhizome develops several branches. This is the easiest alfalfa to propagate vegetatively of all those with which we have experimented.

Several hundred cuttings were rooted in August, 1910. These were put in 5-inch pots and placed in an open frame. In numerous instances during the winter, mice had eaten the crowns of the plants, but this does not seem to have harmed the rhizomes in the least, as they were advanced to such a stage that roots were formed, and in the following summer a single plant in enriched rotten-granite soil covered a space of about 9 square feet. The growth during the first season is comparatively sparse, but dense enough to give abundant grazing material.

This hybrid does not take kindly to heavy clay-loam soils. It evidently prefers a soil which the rhizomes can pierce easily.

The rhizomes of this prostrate alfalfa are very different from those of all other species and forms in that roots are not produced at irregular intervals. On the contrary, as seen in Plate III, figure 2, at every internode numerous small roots are formed, some of which become fairly large the first season, especially after the foliage is produced. When the first growth is fairly well matured, other rhizomes form at a point between 2 to 3 inches from the surface, gradually but surely widening the area of growth. Plate V, figure 1, shows two cuttings only a few weeks old developing rhizomes.

CROSS NO. 389 (S. P. I. NO. 24455 ♀ × S. P. I. NO. 17698 ♂).

The seed bearer, S. P. I. No. 24455, is one of the very hardy forms of *Medicago falcata* procured by Prof. Hansen during his last trip to Siberia. Although it has been planted out for nearly three years alongside S. P. I. No. 20721, unlike the last named it does not grow to be over 12 inches high. It looks to be very hardy, however, judging from the numerous short underground rhizomes.

The pollen-bearing parent, S. P. I. No. 17698, is a plant of *M. sativa* from Chinook, Mont.

Plant No. 389–2.—The hybrid is upright growing with rather thin, wiry smooth stems, which with the rather small leaves would almost be taken for a plant of the Grimm alfalfa. It has not produced flowers thus far. The first-generation plants are very different from those of cross No. 191, which is between S. P. I. No. 20721 and the plant which is the pollen parent of the above cross. The plant is well protected during winter by very numerous short rhizomes, which are placed several inches under ground. The plants of this cross were all late in germinating. It is a promising combination for areas with very severe winters.

SUMMARY.

Among the large number of distinct forms of alfalfa collected mainly through the Office of Foreign Seed and Plant Introduction, some of the plants have revealed underground rhizome-forming characters which seem to be correlated with drought and cold resistance.

Modifications of these characters have been found in some of the cultivated strains, such as the Grimm, Baltic, Turkestan, and Mongolian alfalfas.

In the more tender alfalfas, such as the Peruvian, these characters seem to be absent.

Many crosses have been made between recently discovered rhizome-forming alfalfas and some of the standard varieties, not so much to improve the strains of alfalfa now growing in the alfalfa regions of the United States as to provide pasturage forms which will grow in areas not now suited to the needs of the standard varieties.

PLATES.

DESCRIPTION OF PLATES.

PLATE I. Fig. 1.—A plant of *Medicago sativa gaetula* from northern Africa. In this plant the rhizomes are well developed, the branch at the left being more than 3 feet 6 inches long. The plant is about 2 years old and was found growing in soil composed largely of decomposed rock. This variety may be found to be valuable in the intermountain areas. Fig. 2.—A plant of cross No. 318. Seedling of Grimm, F. C. I. No. 131 ♀ × S. P. I. No. 28042 ♂. The pollen parent is from the Caucasus Mountains at an elevation of 4,000 feet. The seed parent was selected from a field of Grimm alfalfa on Mr. Ensler's farm near Excelsior, Minn., by Mr. J. M. Westgate, of the Bureau of Plant Industry. The seedling Grimm does not have rhizomes, but the male parent is well supplied with rooting rhizomes. In the hybrid the rhizomes are well under the surface of the soil.

PLATE II. Fig. 1.—A plant of *Medicago falcata*, showing a taproot over 5 feet in length, diminishing in diameter very slightly when more than 5 feet below the surface. This plant has pods of the nonshattering form, which makes it valuable for future breeding. Fig. 2.—Nonrooting rhizomes of *M. sativa turkestanica*, showing the gradual development of leaves.

PLATE III. Fig. 1.—A plant showing rhizomatic growth of cross No. 336 (S. P. I. No. 26667 ♀ × S. P. I. No. 26865 ♂), winter condition. All of the rhizomatic growth was developed before the end of October. This cross promises well as a pasture alfalfa. Fig. 2.—Rhizomes of alfalfa cross No. 336 (S. P. I. No. 26667 ♀ × S. P. I. No. 26865 ♂). Rooting rhizomes nearly 2 years old sending out new rhizomes. The dormant buds on the old rhizomes are plainly seen. These rooting rhizomes and resting buds were found 12 inches under the surface of the soil.

PLATE IV. Fig. 1.—A plant of cross No. 336, showing recovery from a severe test which involved cutting the growth 1 inch below the surface of the soil six times during the summer. Fig. 2.—A plant of *Medicago falcata* (S. P. I. No. 26667) from the Crimea; seed-bearing parent of cross No. 336. This plant grows a little over 6 inches high and makes a very dense growth. It may be drought resistant.

PLATE V. Fig. 1.—Rooted cuttings of pasture alfalfa cross No. 336 seven weeks after removal from propagating bed, showing rhizome development. The cuttings rooted in eight days after being placed in sand. Their condition a few months later is seen in Plate III, figure 1. Fig. 2.—A seedling Peruvian alfalfa plant, showing dormant buds unprotected. The crown is above the surface of the soil. This strain is one in which no rhizome-forming influence is apparent. The rhizome-forming alfalfas continue growing long after the Peruvian variety has become dormant at Washington, D. C., but while the growth is generally very abundant it is hidden from view. This fact may explain why the Peruvian alfalfa, which has no underground shoots, has a lower zero point of growth above ground than other alfalfas.

PLATE VI. Plant No. 7 of cross No. 284 (Grimm alfalfa, F. C. I. No. 138 ♀ × S. P. I. No. 28042 ♂.) This plant is seven months from the seed. Some of the rhizomes are more than 3 feet long. One of the oldest rhizomes has developed branches and roots.

PLATE VII. Fig. 1.—A seedling of *Medicago sativa gaetula*, showing the beginning of rhizome growth. The lower buds are 1 inch below the surface of the soil. Fig. 2.—Seedling stages of a rhizome-forming alfalfa (*M. sativa gaetula*). *A*, Seedling with cotyledons developed. *B*, In the second stage the second leaf has only one blade; the next is trifoliate. *C*, Six leaves are seen on the first shoot, the stipules are plainly noticeable, and bacterial tubercles are seen on the root. *D*, The first shoot is nearing its maximum size and is becoming decumbent. The second shoot is starting from the base of the simple leaf. A bud in the axil of the cotyledon at the left may be plainly seen. *E*, Seedlings before attaining this size usually lose their seed leaves. The primary shoot has completed its growth, the secondary shoot from the axil of the simple leaf has made rapid progress, and the buds in the axils of the cotyledons have made considerable progress. The future rhizomes develop from the leaves of these two shoots.

PLATE VIII. Fig. 1.—Inbred seedling of Grimm alfalfa, F. C. I. No. 138. The seed-bearing parent of this plant withstood the winters of Minnesota since the introduction of the Grimm in 1857. The lower part of the crown is well beneath the surface of the soil. The short rooting rhizomes penetrate the soil to a depth of several inches. The crown of this plant spreads rapidly. Fig. 2.—Rooted cuttings of rhizome-forming and nonrhizome-forming alfalfas, three months from the cutting stage. *A*, *Medicago sativa gaetula; B*, Grimm, F. C. I. No. 131. At the lower part of the stem of *M. sativa gaetula* a rhizome has formed three branches, two of which have produced growth above ground. The third branch has descended into the soil. In the Grimm plant no rhizomes have formed and all the growth is above ground.

PLATE IX. Fig. 1.—A 6-months-old plant of Baltic alfalfa (No. C–25 Wheeler). Probably one of the parents of this plant was well supplied with rooting rhizomes. The rhizomes are well under the surface of the soil, and roots will evidently be produced the following season, making a very broad crown in course of time. Fig. 2.—A plant of cross No. 309 (*Medicago sativa gaetula*, S. P. I. No. 28042 ♀ × Grimm, F. C. I. No. 131 ♂). In early autumn the cessation of growth is quite sudden, but for several weeks later the underground rhizomes continue to develop.

PLATE X. Fig. 1.—A plant of *Medicago falcata* (S. P. I. No. 24455) 18 months from seed, one of the hardiest alfalfas. During the first season considerable stooling takes place. During the second season, as the crown enlarges, numerous strong anchor roots are developed, precluding any possibility of heaving. Fig. 2.—One of the original seedlings of cross No. 284 two months after germination. This seedling has developed two rhizomes fully 3 inches below the cotyledon scars and in itself tells the story of the hardy alfalfa, because even in this early stage the dormant buds have 3 inches of soil protection during the winter months.

PLATE XI. Fig. 1.—Flowers and pods of cross No. 191 (*Medicago falcata*, S. P. I. No. 20721 ♀ × *M. sativa*, S. P. I. No. 17698 ♂). Enlarged two diameters. The first flower and pod are from *M. falcata* (S. P. I. No. 20721). The flower and pod in the middle of the illustration are *M. sativa* (S. P. I. No. 17698). The hybrid (first generation) is seen in the flower and pod to the right. Fig. 2.—A plant of *M. sativa* (S. P. I. No. 28152), a wild rhizome-forming form from the Caucasus region.

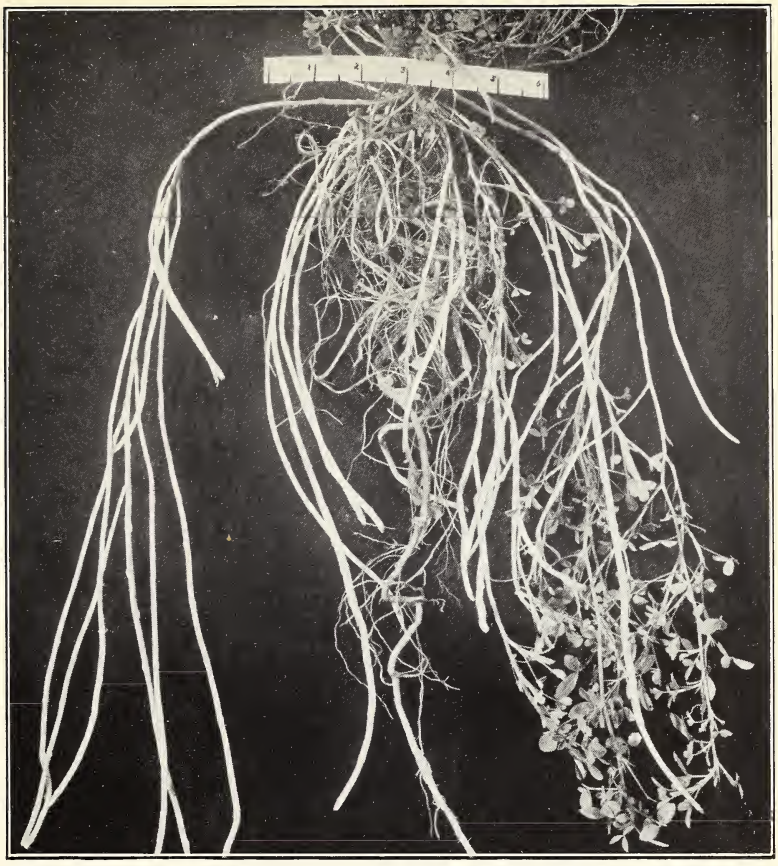

FIG. 1.—A PLANT OF MEDICAGO SATIVA GAETULA, SHOWING RHIZOMES 3 FEET 6 INCHES IN LENGTH.

FIG. 2.—A PLANT OF CROSS NO. 318 6 MONTHS FROM THE SEEDLING STAGE.
Grimm, F. C. I. No. 131 ♀ × S. P. I. No. 28042 ♂.

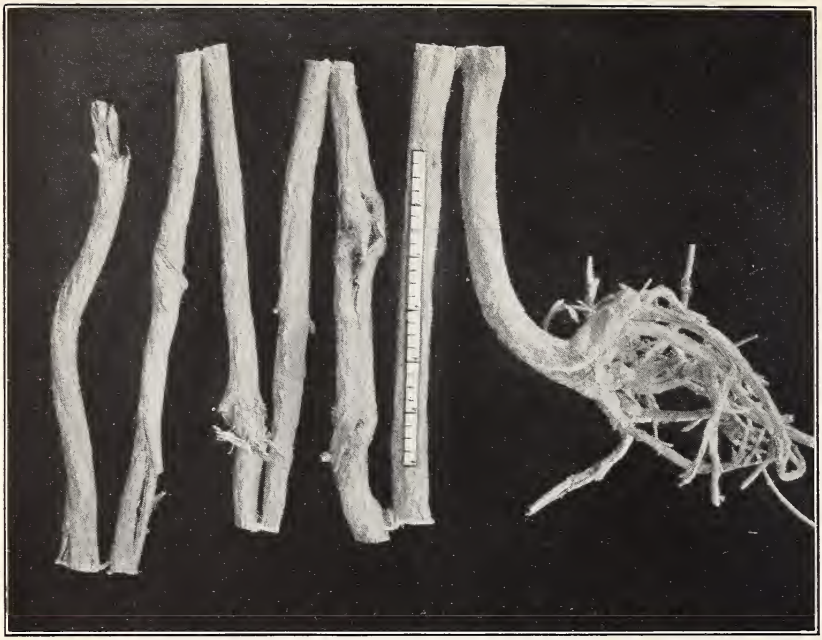

FIG. 1.—A PLANT OF MEDICAGO FALCATA, SHOWING A TAPROOT OVER 5 FEET IN LENGTH, DIMINISHING BUT SLIGHTLY IN DIAMETER.

FIG. 2.—NONROOTING RHIZOMES OF MEDICAGO SATIVA TURKESTANICA, SHOWING THE DEVELOPMENT OF LEAVES.

FIG. 1.—A PLANT SHOWING THE RHIZOME GROWTH OF CROSS NO. 336, WINTER CONDITION.

S. P. I. No. 26667 ♀ × S. P. I. No. 26865 ♂.

FIG. 2 —RHIZOMES OF ALFALFA CROSS NO. 336, WITH RESTING BUDS 12 INCHES BELOW THE SURFACE OF THE SOIL.

FIG 1.—A PLANT OF CROSS NO. 336, SHOWING RECOVERY AFTER A SEVERE CUTTING TEST.

FIG. 2.—A PLANT OF MEDICAGO FALCATA (S. P. I. NO. 26667), THE SEED-BEARING PARENT OF CROSS NO. 336.

FIG. 1.—ROOTED CUTTINGS OF CROSS NO. 336, SHOWING THE BEGINNING OF RHIZOME GROWTH.

FIG. 2.—A SEEDLING PERUVIAN ALFALFA PLANT, SHOWING DORMANT BUDS UNPROTECTED.

PLANT NO. 7 OF CROSS NO. 284.

Grimm alfalfa, P. C. I. No. 138 ♀ × S. P. I. No. 28062 ♂.

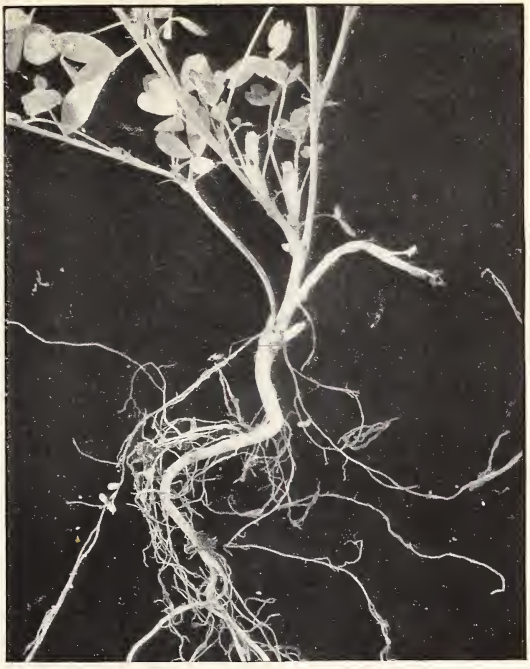

FIG. 1.—A SEEDLING OF MEDICAGO SATIVA GAETULA, 7 WEEKS OLD, SHOWING THE BEGINNING OF RHIZOME GROWTH.

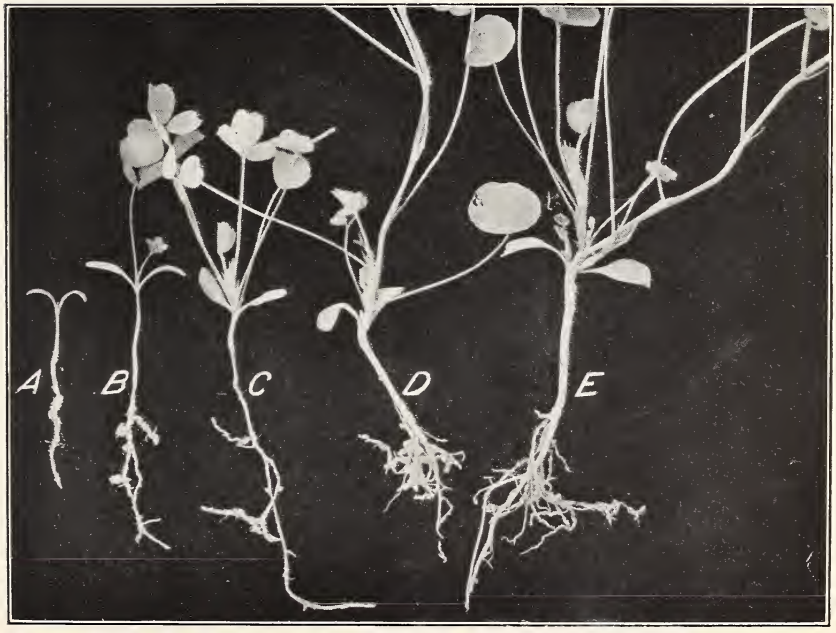

FIG. 2.—SEEDLING STAGES OF A RHIZOME-FORMING ALFALFA.

FIG. 1.—A PLANT OF GRIMM ALFALFA (F. C. I. NO. 138), ONE OF THE HARDIEST OF THIS STRAIN.

FIG. 2.—*A*, A ROOTED CUTTING OF RHIZOME-FORMING ALFALFA. *B*, A ROOTED CUTTING OF ALFALFA NOT FORMING RHIZOMES.

FIG. 1.—A PLANT OF BALTIC ALFALFA (NO. C-25, W. A. WHEELER), AN IDEAL TYPE FOR VERY COLD REGIONS.

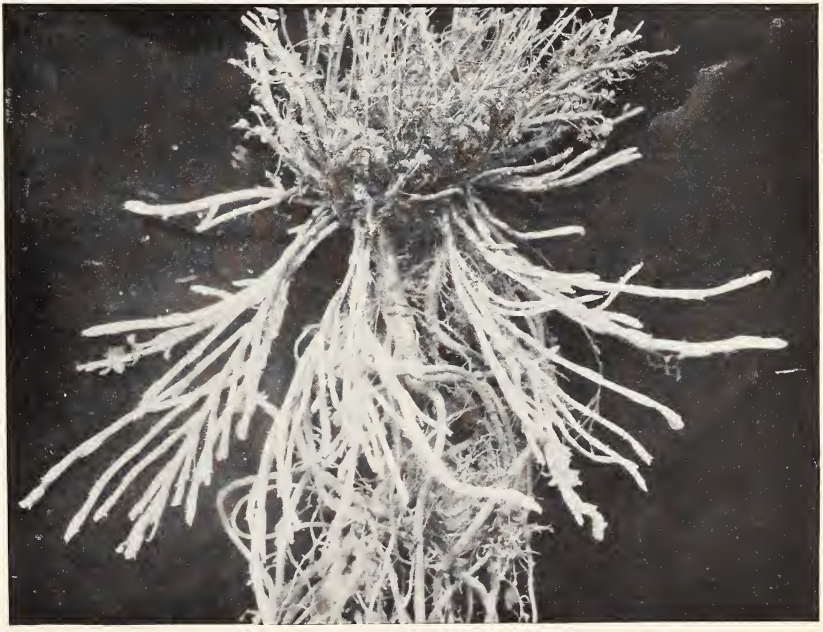

FIG. 2.—A PLANT OF CROSS NO. 309, WINTER CONDITION.
Medicago sativa gaetula, S. P. I. No. 28042 ♀ × Grimm, F. C. I. No. 130 ♂.

FIG. 1.—A PLANT OF MEDICAGO FALCATA (S. P. I. NO. 24455) 18 MONTHS FROM SEED; ONE OF THE HARDIEST ALFALFAS.

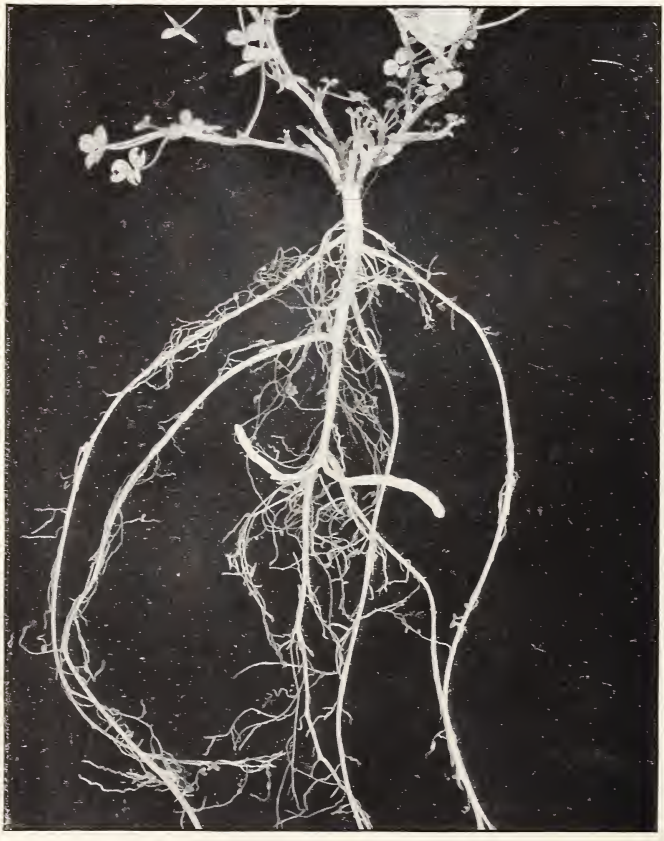

FIG. 2.—A SEEDLING OF CROSS NO. 284, SHOWING RHIZOMES DEVELOPING 3 INCHES BELOW THE CROWN 2 MONTHS AFTER GERMINATION.

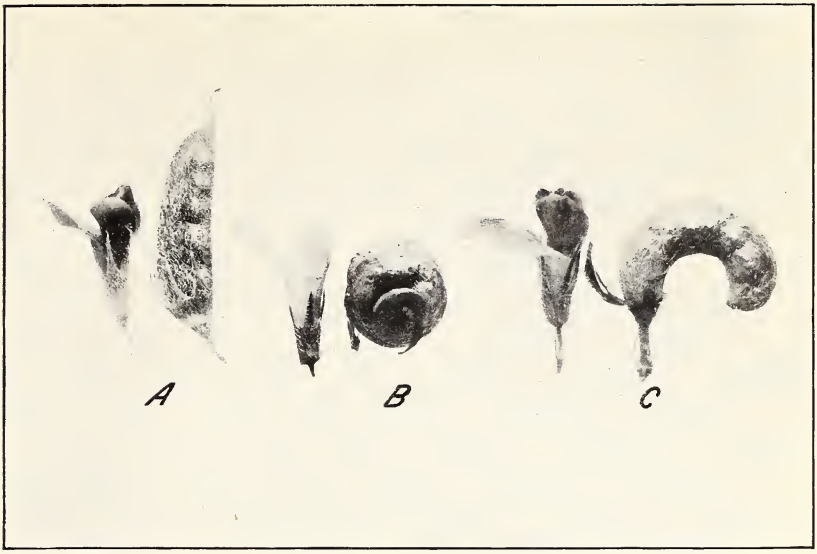

FIG. 1.—FLOWERS AND PODS OF CROSS NO. 191. *A* AND *B*, PARENTS; *C*, HYBRID.
(Enlarged two diameters.)

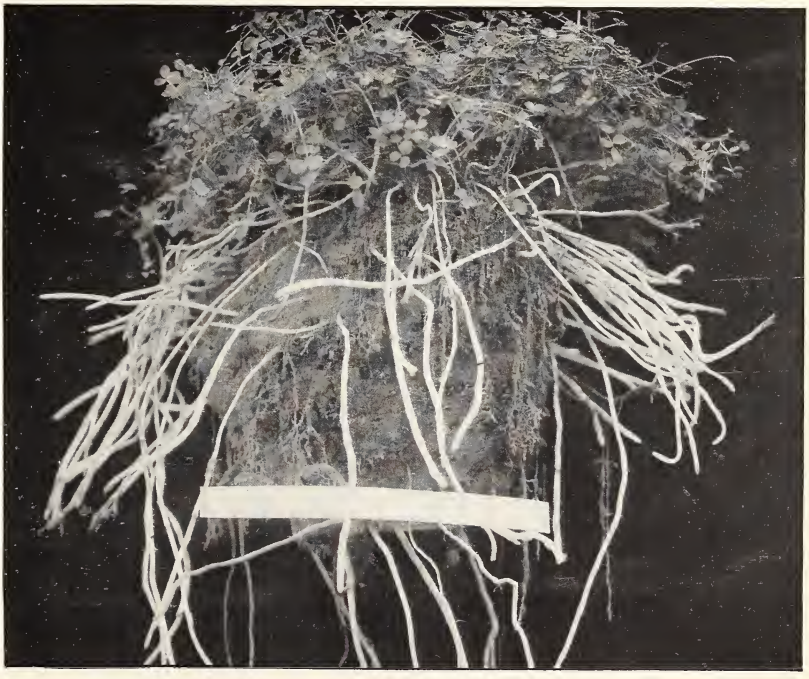

FIG. 2.—A PLANT OF MEDICAGO SATIVA (S. P. I. NO. 28152), A PROSTRATE FORM WITH ROOTING RHIZOMES, AUTUMN CONDITION.